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TRADITIONAL METHOD VERSUS COMPUTER-ASSISTED INSTRUCTION

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AN EXPERIMENT ON MATHEMATICS PEDAGOGY:
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Abstract

The purpose of this study was to determine the effectiveness of computer-assisted instruction (CAI) versus traditional lecture-type instruction on triangles. Two quasi-experiments were conducted in six 6th grade classes with a total of 108 students respectively. The students in the control groups were taught the concepts of triangles in their original classes, while the students in experimental groups were instructed in a computer lab. Experimental group students utilized Interactive Middle School Math Bundle, which is an interactive Webpage-typed tutorial. The tutorial, featuring descriptions, sound, animation and self-examination, allowed students to navigate and self-explore themselves. Independent-*t* was used to analyze the data. The analysis revealed that there was no statistically significant difference between the students' achievement in the control and experimental groups. The result implies that teachers could use computer-assisted instruction software only as a supplemental tool. Further research is recommended to examine effectiveness of computer-assisted instruction with an extended time span.

Keywords: experimental study, middle school mathematics, mathematics pedagogy, computer-assisted instruction

INTRODUCTION

The ratio of numbers of students versus computers in schools has been dramatically decreased. Furthermore, more students have access to computers at home. The availability of technology resources in modern classrooms have enhanced students' mathematical learning opportunities and promoted students' engagements with mathematical ideas (Goos, 2003). The use of computer technology in mathematics teaching furnished multiple functionalities in the classroom, such as assisting computations, drills, and being able to exemplify mathematical concepts visually. The American Mathematics Association of Two-Year Colleges called the importance of pedagogical advantages of technology in mathematics curriculum (Magallanes, 2003).

There is a strong linkage between mathematics and computers because more and more mathematics teachers have used computers in their teaching (Becker, 1991; Hargreaves et al., 2004). Mathematics courseware could be used to customize lessons and tutorials for individual students' needs based on built-in pre-tests (Holland, 2002). Computer-assisted instruction "makes possible programmed instruction which presents students with content, requires the student to respond actively, and immediately gives the student information about the correctness of the response" (Ford and Klicka, 1998, p. 7). Educators have attempted to use technology to enhance mathematics instruction using technology (Duarte, 2000).

Numerous researches have attempted to compare students' performances being taught by traditional type method and computer-assisted instruction method. Traditional mathematics instruction was defined as "teacher-directed instruction using the mathematics textbook, worksheet, hands-on activities, and drill-and-practice activities in large and small groups" and lecture-based classroom teaching (Butzin, 2001; Shults, 2000, p. 13). Computer-Assisted Instruction, on the other hand, "includes the use of the computer for tutorial, drill-and-practice, games, or simulation" (Shults, 2000, p. 25). The current study was a quasi-experimental design comparing traditional mathematics instruction and computer-assisted instruction, starting from reviewing previous relevant research.

REVIEW OF PREVOIOUS RELAVANT RESEARCH

Comparative Studies on Students' Mathematical Achievements

Elementary School

Wilson (1996) studied four elementary students with learning disabilities to compare computer-directed and teacher-directed instruction for student achievement with selected instructional variables. Computer-assisted instruction used *Math Blaster*, a popular computer math software program, while teacher-directed instruction used flashcards. Success rate data revealed the two teaching formats favored the teacher-directed instruction. In Shults' (2000) nine-week long study, both elementary students in the control group and experimental group received traditional instruction covering addition and subtraction facts. In addition, the control group received an hour of traditional instruction while the treatment group used *Math Blaster[R] Jr. Software* for an hour each week. Although the control group mean score was higher than the treatment group, there was no significant difference between the two groups.

In Xavier's (2001) study, math teaching involved with computer-assisted instruction software among 60 third-grade students did not show significant higher scores. Hargreaves, Shorrocks-Taylor, Swinnerton, Tait, and Threlfall (2004) found mixture results in British children's performance on a computer mathematics assessment compared with a pencil-and-paper assessment. A total of 260 randomly selected samples were evenly divided into two groups. Both groups were further given two mathematics pencil-and-paper tests and two computer tests. In the first test, children performed better with the computer medium, while in the second test, there was no significant difference between children's performance.

Secondary School

Rivet (2003) used four sixth grade classrooms in two schools to study students' achievement, retention, and cost-effectiveness of computer-assisted instruction. The researcher compared the students' achievement on fractions using two types of instructional methods – computer-assisted instruction and traditional instruction. Two classes used lecture and a textbook as the primary mode of instruction, while the other two used computer-assisted instruction as the primary means of content delivery. The content remained the same for all four classes. The results approved the hypothesis that the overall improvement scores were significantly higher in computer-assisted instruction classroom than in the traditional classroom. Magallanes (2003) conducted a comparative study of all students who were taking seventh grade pre-algebra on a mathematics domain of coordinate planes using two different types of teaching methods – traditional classroom techniques and traditional techniques coupled with ethnomathematics software. Students' test scores were analyzed using *t*-test at significance level .05 by the end of 2002-2003 school year. The result revealed that there was a significant difference between scores from students who were taught a unit in coordinate planes using traditional teaching methods exclusively and those who were taught the same unit using traditional teaching method coupled with ethnomathematics software. Students who were taught using traditional teaching techniques coupled with ethnomathematics software achieved higher scores than their counterparts.

Rendall (2001) compared eighty ninth and tenth grade remedial math students at a rural public school to detect the effectiveness of computer-based instruction and traditional math instruction. The result demonstrated that computer-based instruction was more effective in raising computational math skills and math reasoning skills. Schpilberg and Hubschman (2003) compared high school students' achievements in using teacher-directed and lecture-based face-to-face tutoring and computer-mediated tutoring learning from August 2001 to November 2001. The data in the study showed that there was no statistically significant difference between face-to-face and the computer-mediated tutored students' mathematical achievements.

Chen (2003) completed a study to determine how "embedded teaching" and "learner-controlled" instruction in a controlled computer-tutoring environment impacted high school students learning algebra. The treatment conditions were divided into three categories: (a) a conventional "Lecture-Demonstration-Practice" in which conceptual knowledge was presented as a coherent entity prior to engagement in problem-solving activities, (b) "Embedded Teaching" in which the computer tutor used examples to demonstrate problem-solving processes before students began practice, and (c) "Learner-Controlled" instruction in which students engaged directly in problem-solving activities. The results revealed that students in the Lecture-Demonstration-Practice group showed higher level of accuracy. The study indicated that students performed better from instruction that emphasized the coherent representations of algebra symbols. Holland (2002) reported that students' pass rates have gone from 69 percent in 1998 to 83 percent at Turner High School in 2000 after students began using the remediation math software.

Macnab and Fitzsimmon (1999) used a cross-session analysis involving 1,184 ninth graders examining students who were instructed with The Learning Equation (TLE), a computer-based resource, comparing their math achievement scores to those who used traditional classroom and materials as their main instructional method. In their final report, they summarized that TLE students scored significantly higher on the Math Achievement Test than did non-TLE students among the total sample; and also TLE students Math Achievement Test scores were significantly in favor of TLE students within-school comparison groups.

College

A total of 543 students participated in the Ford and Klicka (1998) study of the effectiveness of individualized computer assisted instruction in a community college for basic algebra and fundamentals of mathematics courses. Students in CAI group met in a computer lab and used the textbook's computer software and allowed for self-pacing. The other group stayed in the classroom to receive traditional lectures. Results of four semesters were compared using *Chi-square* analysis and showed that students in traditional sections having significantly higher course retention than those in the CAI sections. However, CAI sections had higher final exam passing rate than the traditional sections.

Attributional Factors in Computer-Assisted Instruction

Technology-based programs might also give the learners a more positive attitude (Tierney, 1996). Mevarech (2001) investigated 257 students in two Israel schools on the inferential roles of intrinsic orientation profiles in predicting student's mathematics scores, who were exposed to computer-assisted instruction (CAI). He found that intrinsic students did better on the paper-and –pencil examination, but not the computer, than extrinsically cognitive oriented students. Students who had intrinsic orientations gained higher achievements. His study suggested that measurement of CAI efficacy should include different types of achievement measures.

Mevarech, Silber and Fine (1991) investigated 149 Israeli sixth grade students to examine cognitive and affective variables in computer-assisted instruction of mathematics. The result showed that treatment alleviated more mathematics anxiety for low ability students than did the individualistic treatment, and treatments of computer-assisted instruction both in individualistic and cooperative computer-assisted instruction methods did not show significant difference. The results also demonstrated that students using CAI drill in pairs performed better than those students using CAI drill individually. Lewis (1987) conducted a research on attributional and performance effects in computer-assisted instruction to examine the effects of individualistic and competitive goal structures. The sample size included a total of 54 forth and fifth grade students. The subjects received computer feedback, individualistic feedback, or no feedback over six weeks. The result only demonstrated moderate evidence of variance in mathematics achievement. Female students receiving individualistic feedback performed better than male students receiving competitive feedback, while male student receiving competitive feedback performed better than female students receiving the same feedback.

HYPOTHESES

Review of relevant literature on effectiveness of Computer-Assisted Instruction has illustrated controversial results. Some studies reported the positive impact of technology-enriched learning environments (Coley, 1997); while others showed that the involvement of CAI did not add any favorable preference on students' mathematical achievements. Butzin (2001) indicated that instructional technology had a short history in schools, but it was a subject of debate. There was little definitive research on the pros and cons of instructional technologies. The use of technology in learning mathematics has challenged approaches of both learning and teaching in mathematics education (Perks et al., 2002). However, Goos (2003) indicated that there was little research literature on pedagogical implications of technology as a mediator of mathematical learning. There was a need to examine effectiveness of results of incorporation of technology in pedagogy (Magallanes, 2003).

What are those unique features for this study? First, this study consisted of two experiments to increase reliable consistent findings. Second, the domain the two experiments examined was a topic in geometry. Third, the computer-assisted instruction software was a newly emerging webpage-based interactive CAI software, containing text descriptions, sound, animation, visual graphics, and self-testing quiz which provided prompt feedback.

The following null hypotheses were formulated for this study:

Hypothesis 1: There is no statistically significant difference between the students' post test scores in the control group who received traditional teaching method and in the experimental group who received the computer-assisted instruction method in Experiment 1.

Hypothesis 2: There is no statistically significant difference between the students' post test scores in control group who received traditional teaching method and in the experimental group who received the computer-assisted instruction method in Experiment 2.

METHOD

The Software

The software students used in the experimental group was Interactive Middle School Math Bundle (Interactive Middle School Math Bundle, 2004). Practicing teachers have written the curriculum content for Interactive Middle School Math Bundle. Interactive Middle School Math Bundle consisting of algebra, chance and data, and geometry, could be loaded onto a school local area network and viewed through a browser on workstations or laptops. It allowed students to learn in an interactive, entertaining, and multi-sensory environment. For the purpose of this study, Triangle terminology in the Geometry module was used.

Subjects

A total of 108 sixth grade students participated in this study. A quasi-experimental pre-test/post-test design was used. Fifty-three students participated in the Experiment 1 study, and fifty-five students participated in the Experiment 2 study.

Procedures

Both Experiment 1 and Experiment 2 had identical mathematics curricula. For the purpose of this comparison study, both experiments used the same teaching unit and the same test. This quasi-experimental study included two groups-control group and an experimental group in both Experiment 1 and Experiment 2. The group of students who received face-to-face teacher lecture-based teaching in their original classroom was control group. The group of students who used computer-assisted software in the new computer lab was the experimental group. The experimental group had more flexible time in terms of pace and self-exploration.

Experiment 1

In Experiment 1, a pre-test was given to both the control and experimental groups before the research to ensure students' similar attainment in the testing unit before the research. The result of Independent-*t* (Means 34.74 [Control group]; 41.65 [Experimental group], $df = 51$, $t = -1.50$, $p > .05$) showed that there was no significant difference between two groups pre-test scores.

Experiment 2

In Experiment 2, a pre-test was given to both the control and experimental groups before the research to ensure students' similar attainment in the testing unit before the research. The result of Independent-*t* (Means 47.88 [Control group]; 41.90 [Experimental group], *df* = 53, *t* = 1.35, p > .05) showed that there was no significant difference between two groups pre-test scores.

RESULTS

In Experiment 1, both pre- and post-tests were used to detect whether there was a significant difference between the control group (using traditional lecture method in a traditional classroom) and the experiment group (using Webpage-typed tutorial) of the sixth grade students' test scores. Table I shows the mean, standard deviation, and *t* value of students' test scores.

Table 1

Mean and Standard Deviation for Pre-Test

	Mean	Standard Deviation	*t*
Control Group	34.74	13.67	
Experiment Group	41.65	17.26	
			.14

Mean and Standard Deviation for Post-Test

	Mean	Standard Deviation	*t*
Control Group	54.74	29.24	
Experiment Group	44.82	16.70	
			.12

It seems that the mean scores of both pre-test and post-test do not differ substantially. To evaluate this, an *Independent-t* test was used to analyze the mean scores between the control group and experiment group. For the pre-test of two groups, the means of the two groups were not significantly different (t = .14, df = 51, $p > .05$). For the post-test of two groups, the means of the two groups were not significantly different (t = .12, df = 51, $p > .05$). Therefore, hypothesis 1 has been accepted.

Experiment 2

In Experiment 2, both pre and post tests were used to detect whether there was a significant difference between the control group (using traditional lecture method in a traditional classroom) and experiment group (using Webpage-typed tutorial) of the sixth grade students' test scores. Table II shows the mean, standard deviation, and *t* value of students' test scores.

Table 2

Mean and Standard Deviation for Pre-Test

	Mean	Standard Deviation	*t*
Control Group	47.88	16.37	
Experiment Group	41.90	15.21	
			.18

Mean and Standard Deviation for Post-Test

	Mean	Standard Deviation	*t*
Control Group	56.12	27.31	
Experiment Group	53.52	22.29	

	.72

Inspection of these statistics does not seem that there is a statistically significant difference between test scores. To evaluate this, an *Independent-t* test was used to analyze the mean scores between control group and experiment group. For the pre-test of two groups, the means of the two groups were not significantly different (t = .18, df = 53, $p > .05$). For the post-test of two groups, the means of the two groups were not significantly different (t = .72, df = 53, $p > .05$). Therefore, hypothesis 2 has been accepted.

DISCUSSION

The findings of this study were consistent with those literatures indicating no significant difference between students' mathematical scores being taught by traditional method and computer-assisted instruction (e.g., Schpilberg and Hubschman, 2003; Shult, 2000; Xavier, 2001). At significance .05 levels, results in both Experiment 1 and Experiment 2 concluded there was no significant difference in the mean scores of post tests between students receiving the traditional teaching method and using the computer-assisted instruction method. Therefore, it cannot be concluded that one teaching method was superior to the other. This might imply that teachers could use computer-assisted instruction software as a supplemental tool instead of a separate teaching method isolated from teachers' lectures. Teachers could plan to offer those students who needed additional assistance to use computer-assisted instruction software for extra practices.

Whenever computer-assisted instruction software is properly designed in computer multimedia formats, it can be a powerful aid to mathematics teaching and has potential of facilitating mathematics learning (Moreno and Duran, 2004). The current study did not detect any preferred desire in using computer-assisted instruction. There may be a possibility due to students' familiarity levels in the computing environments. Students with prior knowledge of computers might quickly focus on the content, while students with no or little computing experience might feel overwhelmed with the software interface and the mathematics content as well. This study also implies that teacher educators shape teachers' skills in the use of new computer-assisted instruction software and resources (Ruthven and Hennessy, 2003).

There might be another possibility of the quality of computer-assisted instruction software itself. A well-designed software provides a child thinking skills with prompt interactions and instant feedback built in to the software can accommodate and assimilate information fast (Buckleitner, 2004). Software developers might build the appropriate feedback into their CAI programs.

FINAL REMARKS

In this study, two quasi-experiments were made to examine the relative effects of traditional teaching method and computer-assisted instruction method in facilitating students' acquiring triangle terminology. Both Experiment 1 and Experiment 2 did not show any favorites in either of the two teaching methods. However, with proliferated computers available in schools, computers could be used as an effective instructional delivery tool to improve mathematics education. Providing students with computer experiences of developmentally appropriate activities could be a prerequisite task prior to implementing computer-assisted instruction utilization. Classroom teachers need constant and prompt technology training, so that teachers, in turn, would bring those new technology-related skills to their students.

The purpose of teaching approaches is to improve students' learning (Ford and Klicka, 1998). Computer-Assisted Instruction software provides contingent and frequent feedback and students like computer animation and interactivity, which presented visual interesting to motivate students to learn (Media & Methods, 2002). Computer software improves students' understanding of the nature of the solutions of differential equations (Witt, 1997). New pedagogical trends in mathematics teaching involve integrating technology utilization in the classroom.

Further research on computer-assisted instruction is needed to convert research on effective teaching into teaching methods on how computer-assisted instruction could best be used (Wilson, 1996). Examining advantageous attributes, such as student characteristics, task characteristics, and academic and affective outcomes, would be contributing desirable conditions for CAI programs (Okolo, 2001). This study used pre-tests to avoid the different attainment in the control and experiment groups. A future study may also control possible individual attributions such as prior computer knowledge. This type of study may start introducing computer skills, and have pre-test both in computing skills and the content knowledge prior to the experimental study. The limitation of this study was the single unit (triangle terminology) and in a certain period of time. Further study is also recommended to use a longer period of time in a systematic way to determine how computer-assisted instruction affects students' learning mathematics.

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